Weapons Effects Prediction

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ABSTRACT

This study presents two practical approaches to assisting military staff analyse effects produced on the battlefield. First, a calculator tool for the effects of known indirect-fire weapons systems upon targets is provided. The method in which effects are calculated is based on Australian and United States military doctrine. Using this tool, staff are able to evaluate the effects produced upon targets without consulting tables of ammunition effects or performing complicated calculations. Second, a practical solution to the problem of allocating these indirect-fire weapons systems to targets in order to produce desired effects is discussed. In solving this problem, it is not assumed that targets are necessarily detected, identified or recognised. A sequence of Monte Carlo simulations is conducted to predict the nature of the effects produced. No judgement is made by the software on the relative merits of the effects produced in any of the possible allocations. Hence, the Weapons Effects Prediction software assists, but does not replace, military staff in analysing effects produced on the battlefield.

RELEASE LIMITATION

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Weapons Effects Prediction

Executive Summary

The translation between the available weapons platforms and munitions in the battlespace and the effects that these platforms are able to generate is often a non-trivial task. In particular, the increasing availability of complex mixes of ammunition types and fuses as well as the complications of effects generated by Joint and coalition assets, makes the calculation of effects by hand a lengthy and time consuming process. In this report, a practical framework is implemented in the form of a suite of software tools that provides a user with a calculation tool for the analysis of effects.

The Weapons Effects Predictor software estimates a range of effects that a given collection of indirect fire weapons systems is capable of generating and displays the effects using an open-source Geographic-Information-System. The Weapons Effects Predictor uses an open-source Discrete-Event-Simulator to generate the sets of Monte Carlo results. This simulation capability facilitates the estimation of effects by incorporating nonlinear dynamics and provides a basis for extending the software to include factors such as logistics and terrain.

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Scott Wheeler completed a Bachelor of Science (Ma. & Comp. Sc.) at the University of Adelaide with a major in Computer Science and Applied Mathematics in 1996. He received a HECS exemption scholarship during his honours year and graduated top of his class in 1997. In 1998 he enrolled in a Ph.D. under an Australian Postgraduate Award and completed his studies in 2002. Scott joined DSTO Edinburgh as a Research Scientist in 2003 and currently works in Land Operations Division.

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Contents

1. Introduction

The translation between planning for desired effects on the battlefield and the production of these effects using indirect-fire assets such as Artillery, Mortar, Naval Gunfire Support and Close Air Support is often a lengthy and difficult process. As a result, Australian military staff are extensively trained to plan for the generation of desired effects and to allocate indirect-fire assets both efficiently and effectively in an environment of conflicting priorities and possibly insufficient resources. This study develops weapons effects software to assist staff conduct an analysis of battlefield effects.

We provide a user with a simple tool to calculate the effects produced by various combinations of weapons systems and mixes of ammunition. This tool is developed using the open-source software OpenMap (2004). OpenMap is a geographic-information-system viewing tool. That is, its main functionality lies in the display of graphics and overlays. We define this combination of graphics and overlays loosely as a map. The user of this tool is able to place weapons systems and targets onto the map, as well as setting various attributes of the systems such as ammunition, and can designate targets for the weapons systems. The Weapons Effects Predictor provides a calculation of the effects produced on each of the targets as an output. This calculation is based on Australian and United States military doctrine; specifically, the Australian Manuals of Land Warfare (Australian Army 1995, 1980), Corps Training Notes (Australian Army 1992, 1997a, 2000, 1989, 1997b) and Land Warfare Procedures (Australian Army 2001) are used as well as the United States Army and the United States Joint Services Field Manuals (United States Army 1996a, 1993, 1996b, United States Joint Services 1994, 1978, 1979) Technical Manuals (United States Army 1999) and Special Texts (United States Army 1993).

Inherent in the calculation of effects is the assumption that the weapons platforms are able to engage and prosecute the targets designated to them by the user. A prediction of effects is also provided. In making this prediction the assumption is made that a target may not necessarily be detected. The user is able to change the probability that a given target is detected in three ways. First, the user may change the perceived comparative likelihood of detecting each target. For example, it is easier to detect a regiment of tanks than it is to detect a platoon of infantry. Second, the user may change the perceived ability to successfully conduct Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) operations in a given area of the map of fixed size. For example, it is easier to detect a company of infantry using all available ISTAR systems than it is to detect the same company of infantry using no ISTAR systems at all. Third, the user may change the size of the area to be searched when looking for the enemy. For example, it is easier to detect a target known or suspected to be hiding in a small forest than it is to detect the same target hiding in a large forest. The Weapons Effects Predictor provides an estimation of the relative likelihood of successfully engaging and producing effects on targets as an output.

The allocation of weapons systems to targets is a non-trivial task, made so primarily by the inability to differentiate between the relative merits of two or more different effects. For example, when engaging three enemy tanks would you rather (a) completely destroy one of the tanks, or (b) disable two of the tanks for six hours. The answer to this relatively simple question depends on the original intent of the commander in engaging the enemy. Assume that a commander wishes to retreat from the battlefield and to ensure the safety of his forces after this retreat. Which of the two options (a) or (b) best fulfils this intent? The Weapons Effects Predictor does not replace human decision makers but instead provides a list of possible effects, and the corresponding target designation information, to the user. For the simulation of effects, we have chosen to use Quinone (Dickie *et al* 2004). Quinone, developed by Alistair Dickie for the Australian Defence Force as a part of Project Albert, is an extension of the open-source discrete-event-simulation software Simkit (2004), developed by Kirk Stork and Arnold Buss for the United States Naval Postgraduate School. The Weapons Effects Predictor links to Quinone to provide the user with options for possible effects and target designations.

2. Model

2.1 Definition of Terms

Before explaining how the Weapons Effects Predictor works, we first explain the terms used throughout this paper. Specifically, we discuss what is meant by an effect and then introduce the concepts of suppression, neutralisation and destruction. Refer to Australian Army (2001a) p.3-2; Australian Army (1995) §3-4; Australian Army (2001b) p.3; United States Army (1996) pp.C-3,4 for a concise definition of effects.

Effects: The effect indirect fire has upon targets is divided into two categories as follows:
- *Physical*: Direct damage or injury inflicted by the blast and fragmentation of indirect fire. Damage is further described as *material* when inflicted upon equipment and fieldwork. Injury is further described as *lethal* when inflicted upon personnel as casualties.
- *Psychological*: Reduction in the efficiency, effectiveness and ability of targets to engage in combat. Psychological effects typically include shock and loss of morale.

The extent of the physical and psychological effects experienced by targets defines what is meant by suppression, neutralisation and destruction. However, we have not adopted a rigorous definition of these terms. For example: destruction is often defined as rendering thirty percent of targets permanently inoperable, neutralisation is often defined as rendering ten to twenty percent of targets temporarily unable to engage in combat for a period of twelve to twenty four hours, while suppression is often defined as preventing effective enemy fire upon friendly units. Instead we have adopted a simpler definition of suppression, neutralisation and destruction as follows:

- *Suppression*: Ten percent of targets sustain physical or psychological effects.
- *Neutralisation*: Twenty percent of targets sustain physical or psychological effects.
- *Destruction*: Thirty percent of targets sustain physical or psychological effects.

2.2 Weapons Systems and Targets

The characteristics of eight Indirect Fire Weapons Systems, in common use by the Australian and coalition forces, are modelled in this study. These systems are listed in Table 1. In this table, the minimum and maximum effective ranges (*Min* and *Max* respectively), in kilometres, of systems are provided based upon typical values achieved when firing a conventional high-explosive round. The rate of fire, in rounds per minute, for the weapons systems is measured based on the sustainable rate of fire for the system (*Sust.*) and the maximum rate of fire for the system over the first one minute of action (*Max*). The actual rate of fire used by the gun depends on the effect desired. For example, it is likely that the sustained rate of fire would be used for suppression. The compatible ammunition column classifies the type of rounds each system fires. Values listed in Table 1 are based on an Indirect Fire Weapons Systems engagement systems study (Aerospace Concepts 2003) that in turn cites a number of sources (Australian Army 1992, 1997b, 2001; Janes 2004).

Table 1. Selected Indirect Fire Weapons Systems

Weapons System	Range (km)		Rate (rnds/min)		Compatible Ammunition
	Min	*Max*	*Sust.*	*Max*	
M252 Extended Range 81mm Mortar	0.8	5.9	8	25	M253
120mm M120 Towed Mortar	0.2	7.2	4	16	Smoothbore
GMD 120mm LAV III mounted Self-propelled mortar	0.3	9.2	4	10	Smoothbore
105mm M2A2 Towed Howitzer	2.6	11	3	6	US M1
Hamel 105mm L118 Towed Howitzer	2.3	17.2	3	6	Abbot Mk2
Hamel 105mm L119 Towed Howitzer	2.1	11.4	3	6	US M1
Paladin 155mm M109A6 Self-propelled Howitzer	4	22	1	4	M284 39-Cal
155mm M198 Towed Howitzer	2.4	22	2	4	M107

An effort has been made to ensure that the values used in Table 1 are accurate. However, it is difficult to obtain agreement between sources because of inherent variations in measurement of these values and the way in which these values are presented. For example, rate of fire depends upon the competence of the crew manning the system as well as factors inherent to the system itself. Also, the maximum rate of fire is often reported over different time periods; 1 minute, 3 minutes and 10 minutes are commonly used. Furthermore, the maximum range is also reported using different standards including conventional range-assisted rounds and rocket-assisted projectiles.

A number of additional capabilities are included in this study as special cases. These include Naval Gunfire Support, Close Air Support and Multiple Launch Rocket Systems.

For the purpose of this study, the Indirect Fire Weapons Systems are categorised as units based on the following standard configurations. Mortar is categorised in terms of Mortar Sections and Mortar Platoons. Artillery is categorised in terms of Batteries and Regiments.

Seven types of targets are considered in this study. These are based on generic descriptions of a type of target rather than specific threat weapons systems. The targets studied are: Armour, Mechanised Infantry, Infantry in the open, Infantry in a trench, Infantry under full cover, Mortar and Artillery.

For the purpose of this study, targets are categorised as units based on the following standard configurations. Armour is categorised in terms of a Troop of 3-4 Main Battle Tanks, a Squadron of 10-13 Main Battle Tanks and a Regiment of 36-40 Main Battle Tanks. Mechanised Infantry is categorised in terms of a Platoon of 30 personnel in 3-4 Armoured Personnel Carriers (APC), a Company of 90 personnel in 10-13 APCs and a Battalion of 430 personnel in 36-40 APCs. Mortar is categorised in terms of a Section of 2 delivery systems and a Platoon of 6-8 delivery systems. Artillery is categorised in terms of a Battery of 6 delivery systems and a Regiment of 18 delivery systems.

2.3 Ammunition Characteristics and Effects

2.3.1 Land Delivered Ammunition and Effects

A number of types of ammunition (Australian Army 1997a §1; Australian Army 2001 pp.4-III-1,2; Australian Army 1995 §3-2,§7,§18-3; United States Army 1992 §B-10; United States Army 1996§C-11), in common use by the Australian and coalition forces, are modelled in this study. Ammunition types include:
- Area Denial Anti-personnel Mine (ADAM),
- Anti-Personnel Improved Conventional Munitions (APICM),
- Army Tactical Missile System (ATacMS),
- Copperhead (Cphd),
- Dual Purpose Improved Conventional Munitions (DPICM),
- Hexaclorethane Base Ejecting Smoke (HCBE),
- High Explosive (HE),
- High Explosive Rocket Assisted Projectile (RAP),
- Improved Conventional Munition (ICM),
- Illumination (Illum),
- Remote Anti-Armour Munition (RAAM),
- White Phosphorous (WP).

Rounds are further differentiated by calibre, for example, 81 mm, 105 mm, 120 mm and 155 mm. Rounds may be fused (Australian Army 1997a §1; Australian Army 1995§3-2; Australian Army 1989 pp.6-15,16,17,53,54; United States Army 1996 §10-17) in a number of

different ways depending on the type of ammunition and the intended effect. Fuses include:
- Concrete Piercing (CP),
- Delayed (Dly),
- Point Detonating (PD),
- Mechanical Time (MT),
- Mechanical Time Super Quick (MTSQ),
- Variable Time (VT).

2.3.2 Maritime and Air Delivered Ammunition and Effects

Note that Naval Gunfire Support (Aerospace Concepts 2003 p.4-VI-1) and Offensive Air Support (Australian Army 1997a §2; Australian Army 2001pp.4-VII-5,6,7,8) are included in this study. We model generic instances of
- 76 mm and 5 inch Naval Gunfire Support,
- cruise missiles deployed against land targets,
- air-delivered free-fall precision-guided-munition (PGM),
- air-delivered free-fall non-PGM,
- rocket assisted PGM,
- rocket powered PGM.

For convenience, we henceforth refer to all types of ordnance delivered by the systems in this study loosely as rounds rather than specifically distinguishing between shells, rounds, missiles and bombs.

2.3.3 Lethal Radius and Safe Distance

Each particular round is associated with a lethal radius (Australian Army 1995§7AnnexC; Australian Army 1989pp.6A-1–8; United States Army 1992 §B-2,3,7; United States Joint Services 1979) description. Rounds for which lethal radii are not strictly meaningful in a literal sense, smoke and illumination for example, are still associated with lethal radii descriptions. However, the software interprets these values simply as the radii over which the rounds have effect. For the purpose of simplicity, we define the boundaries of these areas as simple geometric shapes such as ellipses or convex polygons. We classify the battlefield effect of the HCBE and WP smoke, Illum, and ADAM and RAAM rounds as producing an obscuration effect, an illumination effect, and an area denial effect respectively. Descriptions of the minimum safe distances for the rounds are also recorded. Lethal radii and minimum safe distances are not directly used in this study, apart from displaying these regions on users' screens.

2.3.4 Weapons Effects Table

For each Indirect Fire Weapon System given in Table 1 and each type of round, the minimum and maximum ranges of the weapon systems and rounds are recorded (Australian Army 2001,pp. 4-V-3,4; United States Army 1996 §C-7,8,9). These values are

displayed on users' screens. Furthermore, information on the numbers of rounds required to achieve each of the effects suppression, neutralisation and destruction against each type of target in the study is recorded. Table 2 displays the numbers of 155 mm HE, DPICM, APICM and Cphd rounds with PD fuses required to suppress, neutralise and destroy Troops (Tp), Squadrons (Sqn) and Regiments (Regt) of Armour, such as Main Battle Tanks. For security reasons the values in Table 2 are presented for demonstration purposes only and are not representative of actual combat data. Ammunition types that are not deemed effective against armour are denoted with a -.

Table 2: Selected ammunitions use for effects

Target: Armour	Suppression				Neutralisation				Destruction			
	HE	DPICM	APICM	Cphd	HE	DPICM	APICM	Cphd	HE	DPICM	APICM	Cphd
Tp	50	20	-	1	-	50	-	1	-	100	-	2
Sqn	100	40	-	1	-	110	-	2	-	220	-	4
Regt	150	100	-	4	-	210	-	8	-	600	-	16

This study does not directly model the range or trajectory over which rounds are fired. Nor does this study account for the reliability of various types of rounds or non-standard tactical dispersals of targets. Values in Table 2 are interpreted as the average number of rounds required to achieve effects in generic conventional battles and are not specifically tailored to any particular scenario. A ballistics model and a terrain model, addressing these limitations, are planned for a further study.

Notice that the values given in Table 2 do not explicitly take into account the durations over which rounds are fired. That is, a value of 6 rounds could be interpreted as six weapons systems firing a single salvo or a single weapon system firing 6 rounds. Hence, we rely on a user to input a realistic fire plan (Australian Army 1995 §7-15). However, the fire rates for the weapon system is known, see for example Table 1. The Weapons Effects Predictor alerts the user to fire plans that exceed a user defined duration: 1 hour, 6 hours or 24 hours for example. It is acknowledged that the time independence of the table is somewhat simplistic. A more realistic method for the calculation of effects is planned in a further study.

2.4 Weapons Effects Modelling

The Weapons Effects Predictor using the Geographic-Information-System software OpenMap is developed for users as follows. Users are presented with a battlemap displayed as a graphic and define Targeted Areas of Interest (TAI) on this map. These TAIs are restricted to simple geometric shapes such as ellipses or convex polygons. Hence, their area can be easily calculated. Next a number of blue-force (friendly) Indirect Fire Weapons Systems are placed onto the map. These include those platforms listed in Table 1

as well as symbols representing Naval Gunfire Support, Close Air Support and Multiple Launch Rocket Systems. Similarly, a number of red-force (enemy) targets are placed onto the map. The user assigns the Indirect Fire Weapons Systems to one or more TAI and a single target within each of the TAI. Hence, a single weapon system can only engage a single target from each TAI but can engage multiple TAI simultaneously. This feature is, of course, not realistic and is included so that a user can simultaneously receive advice on several possible combinations of targets in the same physical location on the map. For example, a user can overlay two TAI on exactly the same physical location on the map and test two different combinations of targets at the same time, one combination in each TAI. Hence, if a user is unsure of the exact strength of the enemy force somewhere on the map then they are able to hypothesise on several likely enemy Orders-of-Battle (configurations of enemy forces). The user then designates the type and number of rounds available to each weapon system and a desired intent in terms of suppression, neutralisation, or destruction. The Weapons Effects Predictor restricts the user from choosing options that are not practical. For example, the software tests that the ranges of the Indirect Fire Weapons Systems exceed the distances between the systems and the targets and alerts the user when these distances exceed 90% of the maximum possible ranges. The software also checks that the rounds are of the correct type for the desired intent. For example, from Table 2, HE rounds are insufficient to neutralise Armour. Refer to Figure 1 for an example of the geographic-information-system component of the software and information on one of the entities displayed on the geographic-information-system.

The Weapons Effects Predictor produces as an output to the user a measurement of the effects produced upon each target. This calculation is performed as follows. The numbers of rounds of each type fired at each target in each TAI is totalled. For example, if two Indirect Weapons Fire Systems fire 25 155 mm HE rounds with PD fuses at an Armoured Squadron in TAI 1 then only the total number of 50 155 mm HE PD rounds is relevant. The number of rounds required to suppress, neutralise and destroy the Armoured Squadron is known. For example, from Table 2 an Armoured Squadron can be suppressed with 100 155 mm HE rounds. Then, we say that the target is $(50/100) * 100 = 50\%$ suppressed. Now suppose that a third weapon system fires 90 155 mm DPICM rounds at the Targeted Area of Interest. Then, the target is further suppressed by $(90/40) * 100 = 225\%$ to a total of 275%. Likewise, that target is neutralised by 100% and destroyed by 50%. This example only makes reference to a single type of weapon system, namely a 155 mm system, and a single type of target, namely an Armoured Squadron. However, this example is constructed without loss of generality. The calculations we use extend to all Indirect Fire Weapon Systems and target types in the study, provided the respective tables for ammunition effects are known. That is, it is just as easy to calculate the effects of arbitrary mixes of Naval Gunfire Support, Offensive Air Support, Mortar, Multiple Launch Rocket Systems, and Artillery, as it is to calculate the effects of 155 mm artillery in our example.
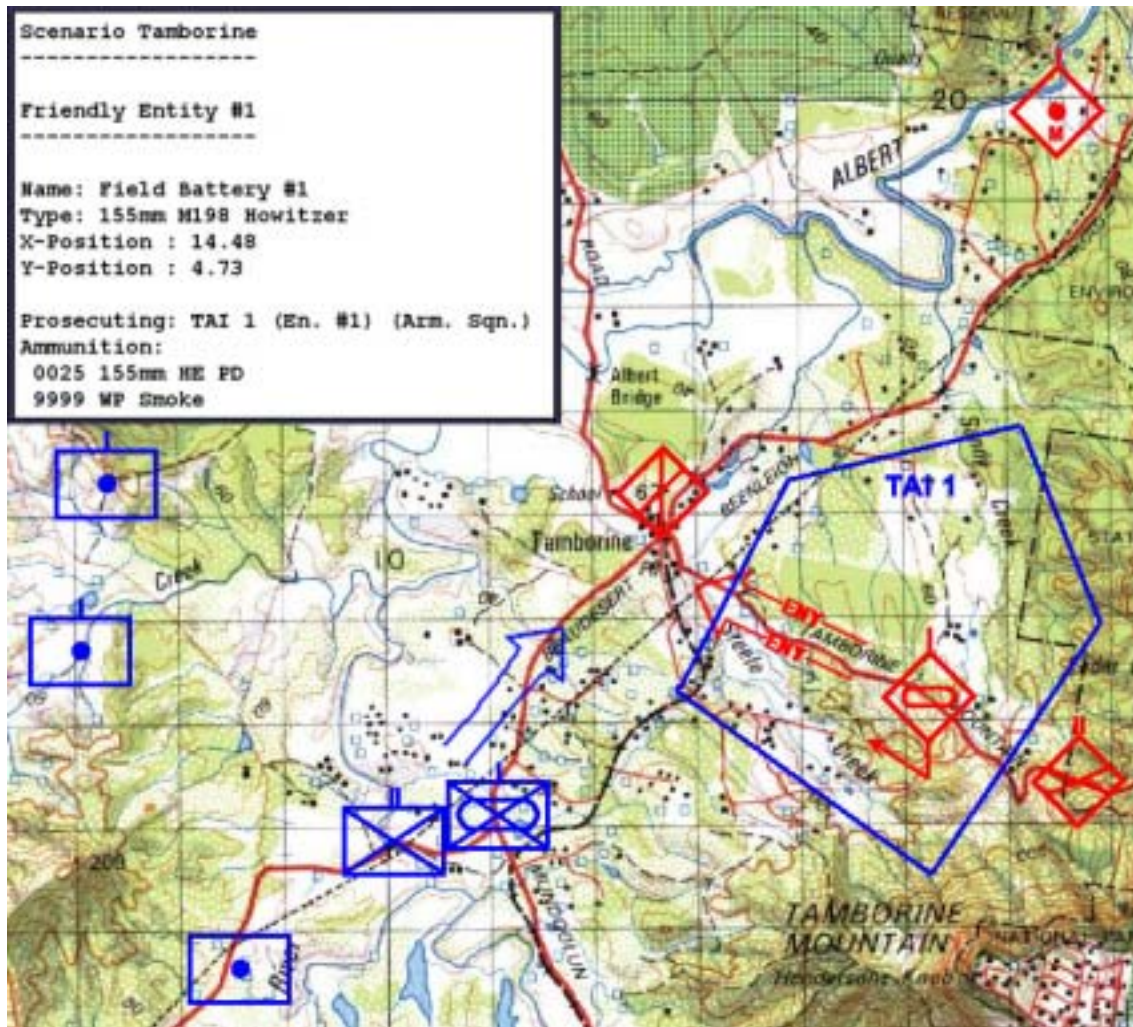
Figure 1: Example GIS view

The calculations of effects performed above naïvely assumes that the Armoured Squadron is successfully detected, recognised and identified by, for example, a Forward Observer assigned to TAI 1. That is, we have performed a calculation of weapons effects and not a prediction of weapons effects. We now propose to take into account the ability of the blue-force to perform ISTAR operations in the named TAI. We assert that a TAI of sufficiently large area is impossible to monitor in any practical way. That is, it may be possible to destroy any target detected in such a TAI but be impossible to locate any targets. We propose a practical, if somewhat simplistic, solution for a prediction of this nature. Each target t is assigned a weight $w(t)$ between zero and one. This value models the perceived comparative likelihood of detecting target t. For example, it is easier to detect an Armoured Squadron than it is to detect an Armoured Platoon. This value is treated as a scaling factor and is not necessarily the same for identical enemy units in all TAIs. Each TAI i is assigned a coverage $c(i)$ in square metres between 0 and its area $a(i)$. This value models the blue-forces ability to conduct ISTAR operations simultaneously over TAI i.

Then, the probability $p(t,i)$ of target t being successfully detected, recognised and identified in TAI i is $p(t,i) = w(t) \, c(i) \, / \, a(i)$. Let $s(t)$, $n(t)$ and $d(t)$ be the percentage values calculated above for suppression, neutralisation and destruction of target t, where scores above 100% are reduced to 100%. Hence, the expected values of the effects produced on target t are $E[t$ is suppressed$] = p(t,i) \, s(t)$, $E[t$ is neutralised$] = p(t,i) \, n(t)$ and $E[t$ is destroyed$] = p(t,i) \, d(t)$. For example, let $a(\text{TAI } 1) = 1{,}000{,}000$ m², $c(\text{TAI } 1) = 500{,}000$ m² and $w(\text{Armoured Squadron}) = 0.8$. Then, performing the prediction of effects described above, we obtain $E[\text{Arm. Sqn is suppressed}] = 0.4 * (\min \{100, 275\}) = 40\%$, $E[\text{Arm. Coy. is neutralised}] = 0.4 * 100 = 40\%$ and $E[\text{Arm. Coy. is destroyed}] = 0.4 * 50 = 20\%$. These values reflect the probability that, knowing or suspecting that an Armoured Squadron is in TAI 1, the blue-force is able to fulfil the original intent of either suppressing, neutralising or destroying the unit.

We now discuss not the calculation or prediction of effects on the battlefield but the way in which Indirect Fire Weapons Systems are allocated targets. Suppose we wish to know how best to allocate a number of weapon systems with a fixed supply of rounds of known types to a number of TAIs and then to plan for the engagement of a number of enemy targets with a desired intent of either suppressing, neutralising or destroying the targets in these TAIs. For this purpose we employ Quinone (Dickie *et al* 2004), a modelling tool build upon Simkit (2004). Quinone was specifically designed to study the effects of allocating weapon systems and sensors to TAIs under varying forms of combat service support. We do not make use of the extended abilities of Quinone to model logistics beyond setting the number of rounds available to each weapon system. However, Quinone is perfect for the simulation of simple effects and the study of different arrangements of weapons systems. Hence, we link Quinone to the Weapons Effects Predictor to exploit Quinone's modelling abilities and the Weapons Effects Predictors calculation and prediction algorithms. This synergy works as follows. The Weapons Effects Predictor provides Quinone with a number of alternative automatically generated allocations for the Indirect Fire Weapons Systems to the TAIs and the targets in the TAIs. Currently, this generation is performed by complete enumeration. It is acknowledged that this is not a scalable approach. Future revisions of the software will address this issue. Next, for each of these allocations Quinone runs a number of Monte Carlo simulations, using the Weapons Effects Predictor to calculate effects, and returns averaged values for the actual suppress, neutralise and destroy percentages obtained over the Monte Carlo simulations for each target in each TAI. A list of these results over all alternative allocations is logged into a file, one allocation per row. For example, the row entry

$$(1:1) \ (2:1) \ (3:1) \sim [1=56,37,11] \ [2=0,0,0],$$

is interpreted as weapon systems 1, 2, and 3 assigned to target 1 giving the suppression, neutralisation and destruction scores of 56%, 37%, and 11% respectively for target 1 and 0% on all counts for target 2. The type of weapons systems and targets associated with the numbers 1 through 3 and 1 through 2 respectively are identified within the Weapons Effects Predictor. In this example, the log file contains 8 rows, one for each possible combination of three weapons systems to two targets. The outputs of these simulations are interpreted as a stochastic prediction or estimation of the likely effects produced on

targets. The Monte Carlo sampling and the averaging of results over a number of simulations provide users with empirical expectations for the effects produced.

3. Discussion and Conclusions

The software developed in this study is both flexible and extendable. For example, the Weapons Effects Predictor and Quinone may be replaced with other alternative tools offering enhanced realism or greater fidelity models. Furthermore, it is possible to extend the study to include, for example, the effects produced by armed reconnaissance helicopters and direct-fire platforms such as tanks. Potentially, the scope of the tool could be increased to include realistic terrain and ballistics models. With such additions, areas on the map that are obscured from the weapons systems by terrain such as hills or valleys could be identified and shaded. Also, the user could be alerted to weapons effects produced in proximity to friendly or civilian forces.

We have presented a simple and practical framework for the definition of weapons effects prediction. This study contains no meta-metrics for optimisation but merely performs calculations based on factual data obtained from Army doctrine. The software does not judge any results produced but collates and presents them to a user. Hence, the user has complete control over any and all decisions made. The tool is not designed to replace humans analysing effects in field operations. However, the tool has a potential to assist and facilitate the user in this task.

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19. ABSTRACT
This study presents two practical approaches to assisting military staff analyse effects produced on the battlefield. First, a calculator tool for the effects of known indirect-fire weapons systems upon targets is provided. The method in which effects are calculated is based on Australian and United States military doctrine. Using this tool, staff are able to evaluate the effects produced upon targets without consulting tables of ammunition effects or performing complicated calculations. Second, a practical solution to the problem of allocating these indirect-fire weapons systems to targets in order to produce desired effects is discussed. In solving this problem, it is not assumed that targets are necessarily detected, identified or recognised. A sequence of Monte Carlo simulations is conducted to predict the nature of the effects produced. No judgement is made by the software on the relative merits of the effects produced in any of the possible allocations. Hence, the Weapons Effects Prediction software assists, but does not replace, military staff in analysing effects produced on the battlefield.